Drink up

The force that keeps cups from overflowing also helps birds eat

Feeding against gravity

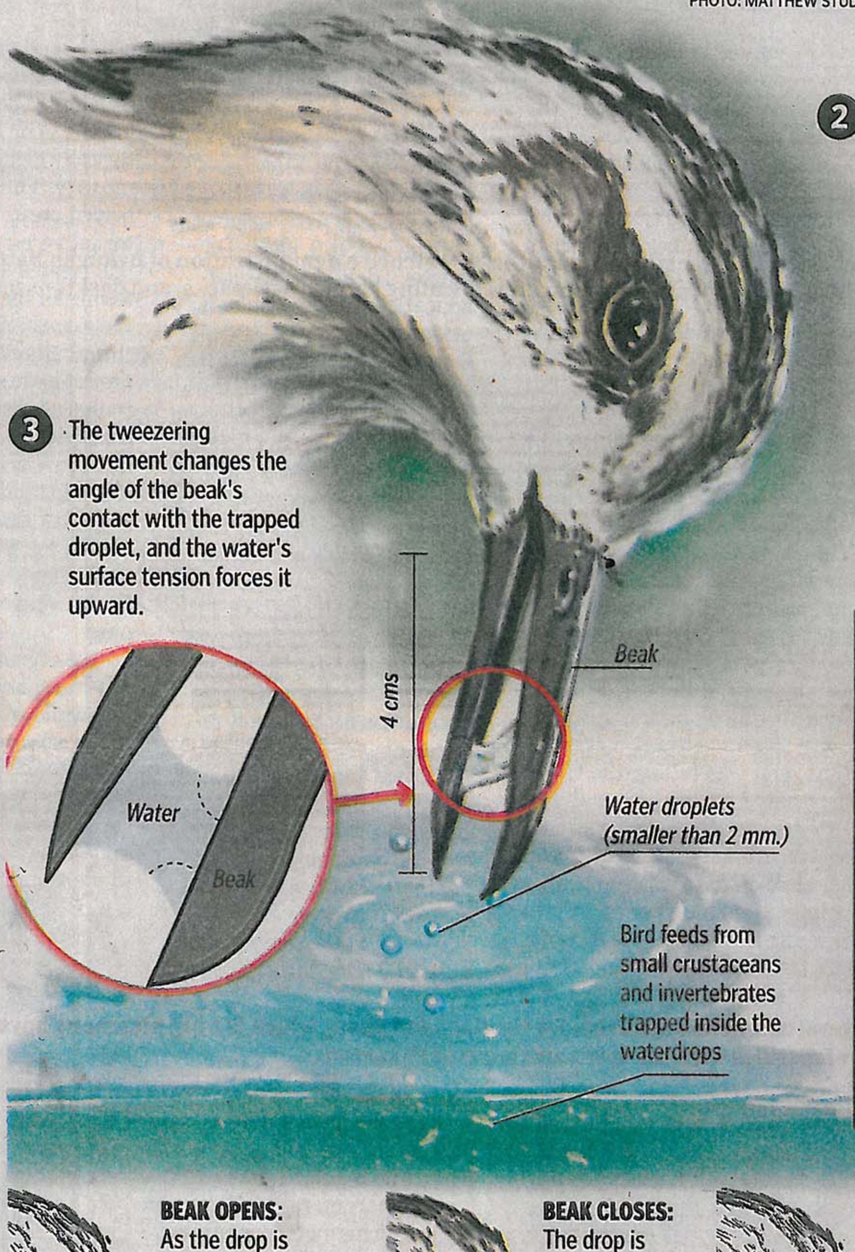
MIT researchers have figured out how the phalarope, a shorebird with a long, narrow beak, transports its food from the tip of its beak to its mouth.

1 By swimming in a tight circle on the water's surface, the bird generates a vortex that draws its tiny prey to the surface

PHOTO: MATTHEW STUDBAKER

2 The phalarope pecks the water's surface, capturing tiny water droplets in its beak. By slightly and quickly opening and closing its beak in a tweezering motion, the bird is able to drive the droplets upward, even with its beak pointed downward.

3 The tweezering movement changes the angle of the beak's contact with the trapped droplet, and the water's surface tension forces it upward.



Bird feeds from small crustaceans and invertebrates trapped inside the waterdrops

Pollutants, such as an oil spill, alter the surface tension of the droplets and make it impossible for these birds to feed, quickly putting them at risk for starvation.

BEAK OPENS: As the drop is stretched slightly, the lower part inches upward more than the upper part. The droplet's surface tension keeps it from falling out of the beak and helps propel it upward.

BEAK CLOSES: The drop is squeezed and the upper part moves more than the lower part, again, inching it up toward the mouth.

REPEAT: On average, it takes only two or three tweezering motions to propel the drop from the tip of the beak to the mouth. The phalarope intuitively uses the most efficient motion possible -- if its beak were shorter or tweezering motion bigger, the drop would not climb as quickly.

SOURCE: Science, May 2008

JAVIER ZARRACINA/GLOBE STAFF

By Michelle Sipics
GLOBE CORRESPONDENT

If you're a researcher hoping to discover a new scientific mechanism, John Bush has bad news for you: You're too late.

"Most every problem you can imagine has been solved by nature," says the MIT mathematics associate professor. "Nature got there first. All that is left is to rationalize nature's designs, many of which are remarkably subtle."

But Bush also has good news: He sees nature's perennial first-place finishes as an opportunity. Along with MIT Media Lab graduate student Manu Prakash and physicist David Quéré of the National Center for Scientific Research in Paris, he has been using nature's designs to inspire and inform new technological ones.

His current passion: surface tension. The surface of a liquid behaves like stretched elastic — which is what allows raindrops to stick to windows and coffee to sit just above the top of a full cup without spilling. Most of his past research has focused on the famous ability of bugs known as water striders to walk on water using surface tension. Now, the mathematician has moved on to a less obvious role for surface tension: the feeding habits of shorebirds.

If you spend time on the coast, you might have seen a phalarope scoop up droplets of water in its beak. Those droplets contain its prey — typically small crustaceans.

But a bird's beak isn't like a straw; it can't use suction to pull lunch into its mouth. And gravity isn't enough to pull a tiny droplet down the beak, even if the bird tips its beak upward. The drop will just sit there, clinging to the beak's inner surface. Instead, Bush and his colleagues discovered that the phalarope actually exploits the surface tension of the water droplet.

By opening and nearly closing its beak very quickly, the bird essentially "pulls" the water into its mouth. If you could watch in slow

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Surface tension helps shorebirds drink up

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motion, you would see the sides of the droplet move up the beak toward the mouth asymmetrically: its trailing edge retreats when the beak opens, while the leading edge advances as it closes.

Bush and his colleagues replicated the system by building stainless steel mechanical beaks that behave similarly to the natural beaks and which revealed yet another insight when the researchers experimented with different liquids: the potential effect of pollution on the birds' ability to feed.

"Pollution changes the wetting properties of the beaks," making them slipperier, Bush explains, so that the droplets can't be pulled into the mouth. "If you have a beak which is covered in oil, these birds can't eat."

The research, published in the May 16 issue of Science, also identifies potential applications for exploiting surface tension the way the shorebirds do. Bush is particularly interested in microfluidics — the motion of fluids at very small scales, prevalent in devices like the so-called "lab on a chip." Such technology can be used in biosensors that, for example, detect chemical agents in the air or pathogens in a sample of blood. By incorporating the ratcheting motion of the birds' beaks, he says, scientists may be able to increase the efficiency of droplet transport and eliminate the need for pumps in some microfluidic devices.

Mark Denny, a professor of biology at Stanford who wrote an accompanying Perspective article in Science, highlights Bush's research for yet another reason.

"The combination of engineering, physics, and applied math is just wonderful," he says, solving a problem that researchers from each of those fields could never have solved alone.

Denny also agrees with Bush that the best answers to a problem are waiting to be found in nature.

"There are some aspects of this that are just so bizarre," says Denny. "If you took any engineer or applied mathematician and told them to design a way for a bird to get water from its beak to its mouth, they wouldn't have thought of this one."

Fortunately, nature already did.